

Progressive Engineering Inc.

ASTM C 473-06a Flexural Strength (Method B)

Date: 12/8/2007 Project No.: 2007-1805
 Client: mSolve Building Science Service Test Condition: 69.0 °F and 29% R.H.
 Load Rate: 1" per minute

Specimen: 5/16" Gypsum (Vinyl Covered) - Murphy Home

Flexural properties of gypsum panel products were evaluated by supporting the 12" x 16" specimen near the ends (14" span) and applying a load at the midspan.

Test No.	Test Sample	Sample Alignment	Maximum Load Reached	Failure Description
1	A2-FS	Vinyl Side Facing Up	115 lbf	Core and bottom paper broke at midspan
2	B1-FS	Vinyl Side Facing Up	119 lbf	Core and bottom paper broke at midspan
3	C1-FS	Vinyl Side Facing Up	114 lbf	Core and bottom paper broke at midspan
4	C4-FS	Vinyl Side Facing Up	117 lbf	Core and bottom paper broke at midspan
5	D3-FS	Vinyl Side Facing Up	117 lbf	Core and bottom paper broke at midspan

Average Max Load Reached	Minimum Breaking Load per ASTM C1396-06a		
	Edge Parallel Facing Side Up	N/A	21 lbf
	Edge Parallel Facing Side Down	N/A	21 lbf
	Edge Perpendicular Facing Side Up	N/A	62 lbf
	Edge Perpendicular Facing Side Down	N/A	62 lbf
	Samples as listed above	116 lbf	

Comments/Observations: The specimens for this test were kept in the AS RECEIVED packaging until the time of test. The samples were removed from the packaging, cut to size and immediately tested. This procedure was repeated for each sample. There was adhesive on a few samples and this was scraped off prior to testing. The direction of the adhesive line was parallel to the 16" dimension and would indicate that the samples were cut parallel to the framing and thus in the machine direction of the board, assuming a vertical installation. This assumption would set the requirement for these samples at 62 lbf per ASTM C1396.

*Progressive Engineering Inc.***ASTM C 473-06a Core Hardness (Method B)****Date:** 12/8/2007**Project No.:** 2007-1805**Client:** mSolve Building Science Service**Test Condition:** 70 °F and 27% R.H.**Load Rate:** 1" per minute**Specimen:** 5/16" Gypsum (Vinyl Covered) - Murphy Home**Core Test**

Test No.	Sample	Test A	Test B	Test C	% 15 off Replacement
1	A1-CH	36 lbf	29 lbf	31 lbf	
2	B2-CH	32 lbf	30 lbf	32 lbf	
3	B3-CH	35 lbf	33 lbf	30 lbf	
4	C3-CH	34 lbf	32 lbf	38 lbf	35 lbf
5	D2-CH	30 lbf	26 lbf	34 lbf	33 lbf

Average = 32 lbf**Minimum Hardness = 26 lbf****per ASTM C 473-06a**

Comments/Observations: The samples used for this test were cut from the same specimens used for moisture content testing. The typical result was a 2" fracture in the gypsum core, extending longwise to the paper edges on either side of the puncture. The fracture typically terminated at the same paper side but in a couple of instances broke through the core diagonally and terminated on opposing paper faces.

*Progressive Engineering Inc.***ASTM C 473-06a Nail Pull Resistance (Method B)****Date:** 12/8/2007**Client:** mSolve Building Science Service**Project No.:** 2007-1805**Test Condition:** 70.0 °F and 29% R.H.**Load Rate:** 1" per minute**Specimen:** 5/16" Gypsum (Vinyl Covered) - Murphy Home

Test No.	Test Sample	Maximum Load	% 15 off Discard	Comments/Observations
1	A1-NP	96 lbf		The samples used for this test were cut from the same specimens used for moisture content testing. Vinyl Side UP. Nail head cut the vinyl and the back of the board had an approximate 2" diameter bulge in the paper.
2	B2-NP	91 lbf		
3	B3-NP	92 lbf		
4	C3-NP	69 lbf		
5	D2-NP	74 lbf		

Average = 84 lbf

Minimum Resistance = 46 lbf
per ASTM C 1396-06a

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Moisture Content - Oven Dry

Date: 12/10/2007

Client: mSolve Building Science Service

Project No.: 2007-1805

Cond. Temp.: 113°F

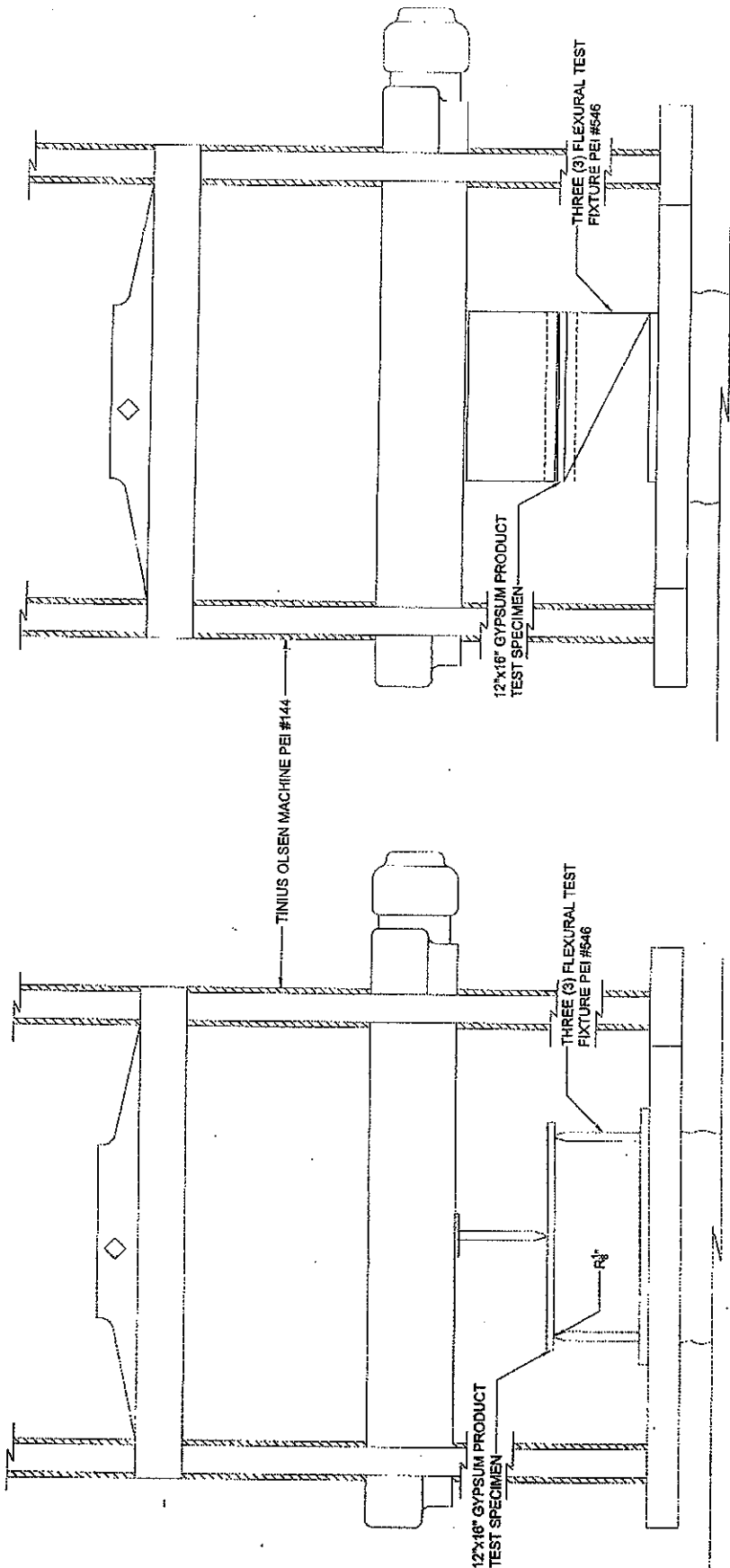
Cond. Humidity: Uncontrolled

Specimen: 5/16" Gypsum (Vinyl Covered) - Murphy Home


Test: Condition the samples at 113°F until a constant weight is attained. Place the samples in a desiccator chamber, allow to cool, and then re-weigh. Determine the total weight loss and calculate the moisture content as the percent weight loss.

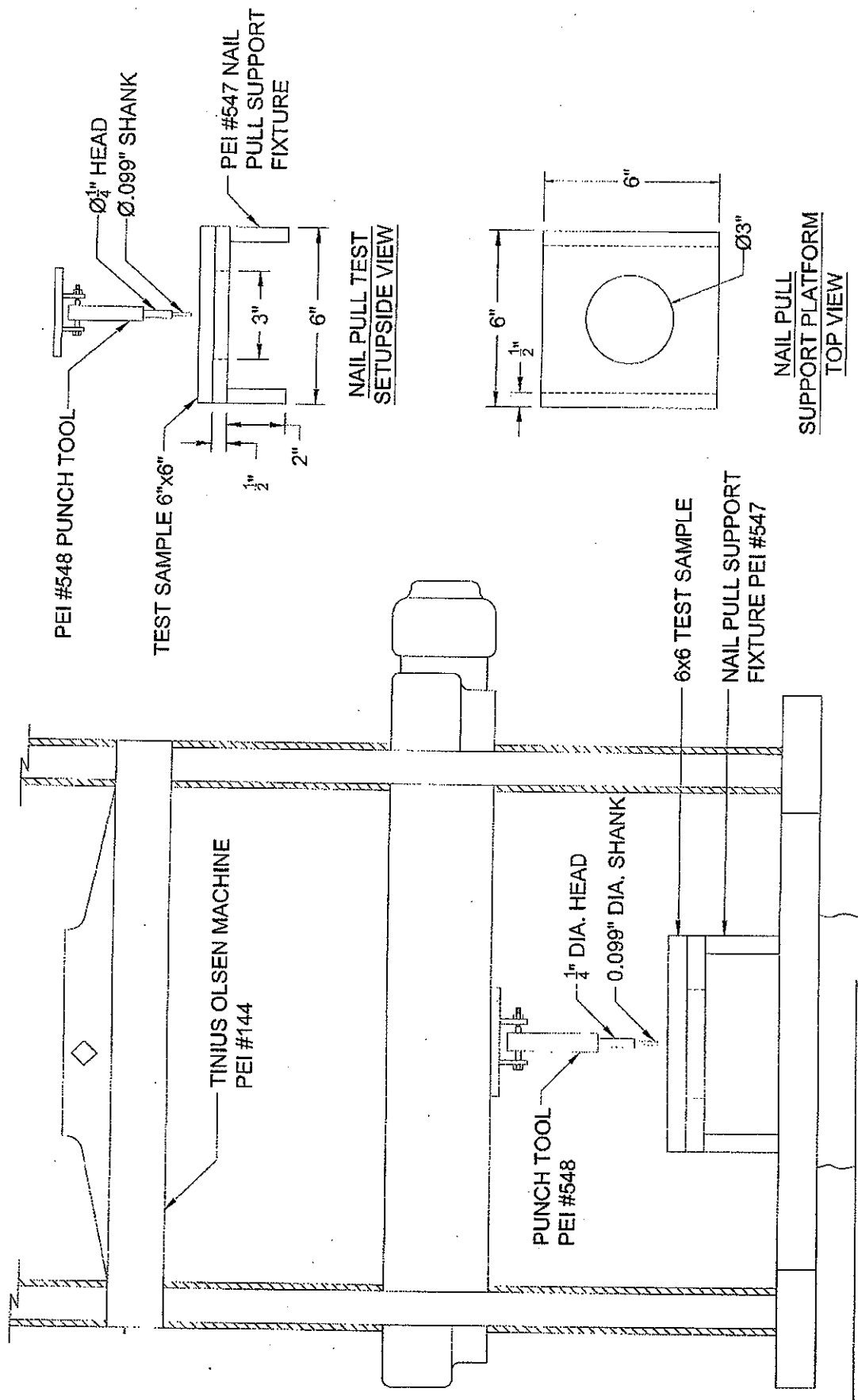
			SAMPLE No. / Weight in Grams (g)				
	Date	Time	A1 - MC	B2 - MC	B3 - MC	C3 - MC	D2 - MC
Initial Weight	12/7/07	19:30	61.35	61.47	61.79	60.61	60.80
DRY Weight	12/10/07	18:00	60.96	61.10	61.41	60.23	60.46
Total Weight Loss (g):			0.39	0.37	0.38	0.38	0.34
Free Water Moisture Content:			0.64%	0.60%	0.61%	0.63%	0.56%

Average Moisture Content: 0.61%



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 Progressive Engineering Inc. 58040 State Road 19 Goanah, IN 46528 Phone (674) 533-0337 Fax (674) 533-9738 www.p-e-i.com			

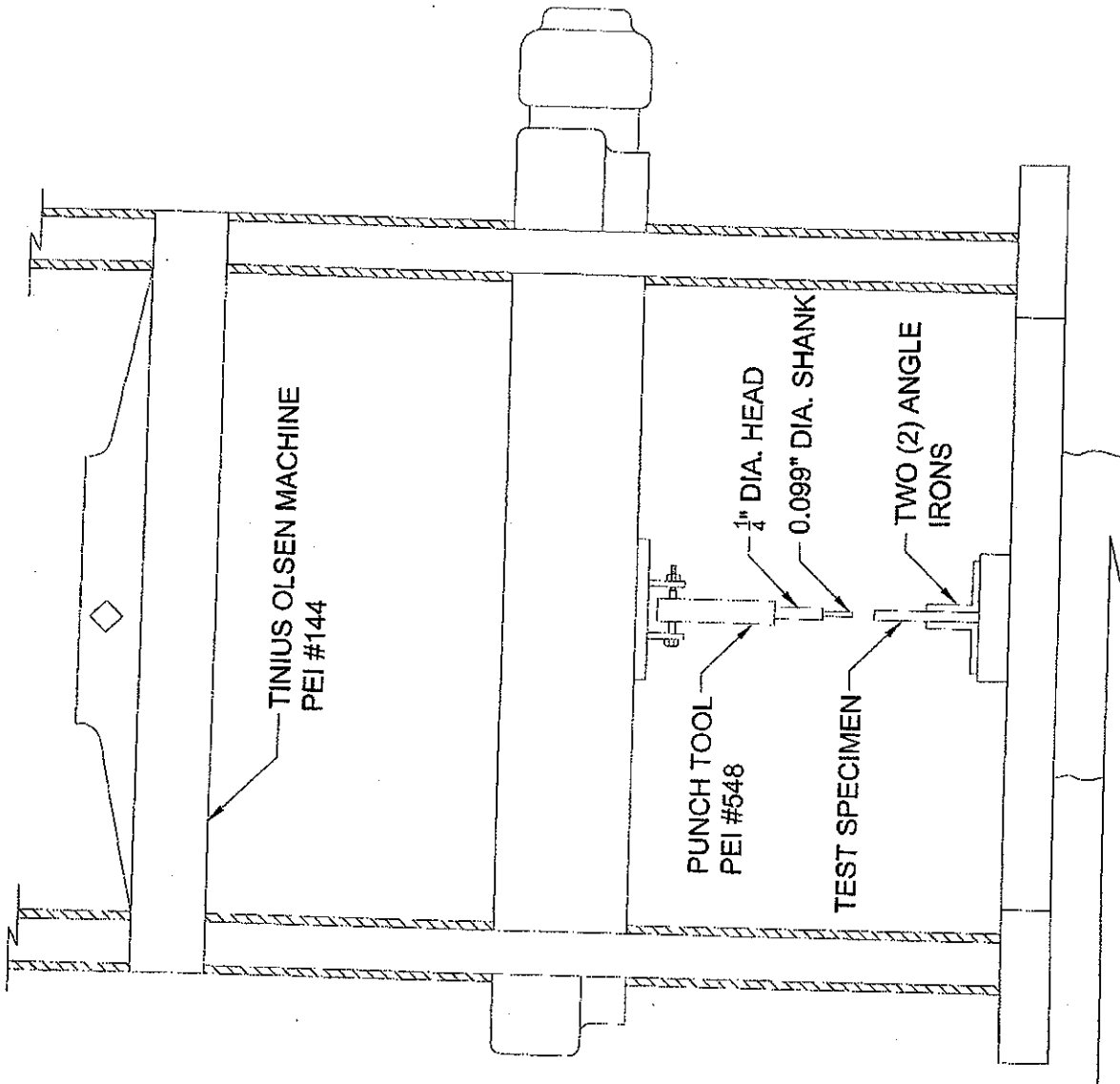



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DATE: 6/15/05
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DRAWING NUMBER: F971

TEST SET-UP

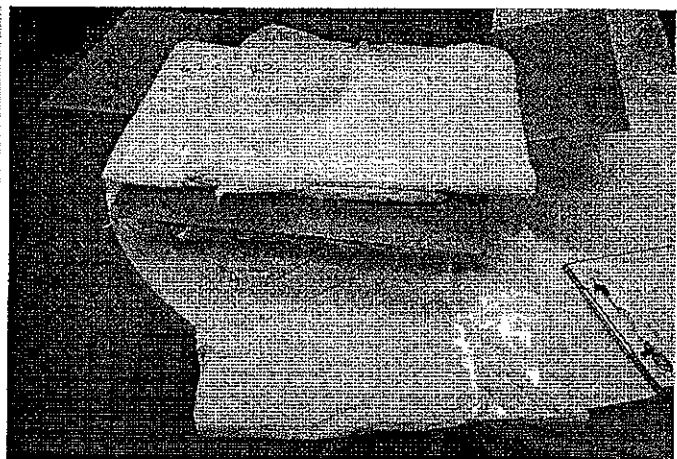
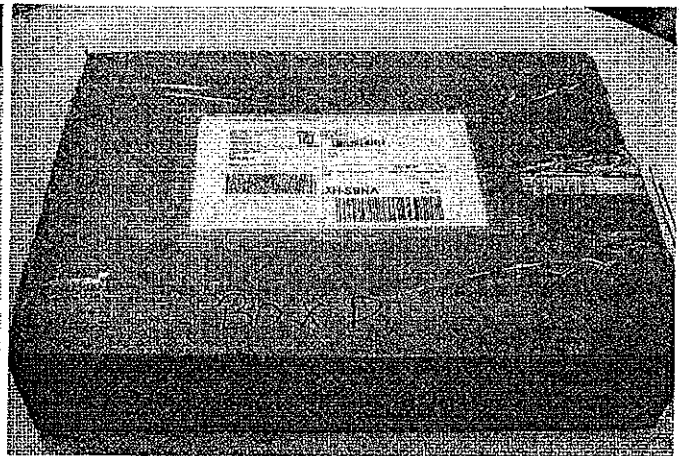
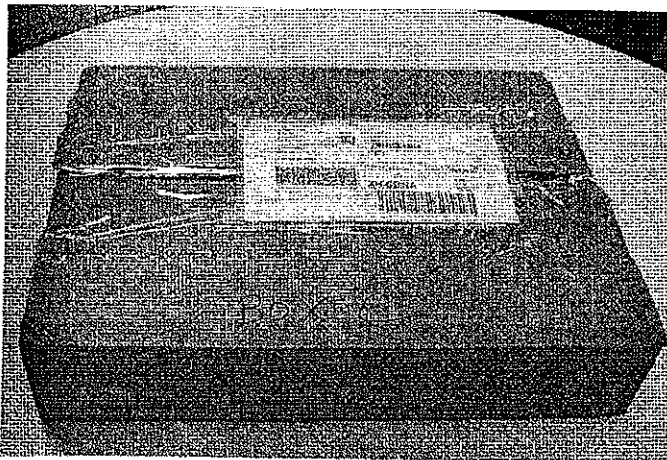
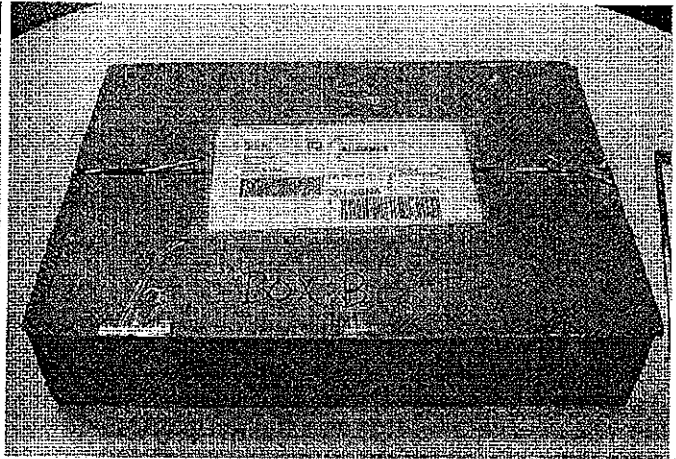
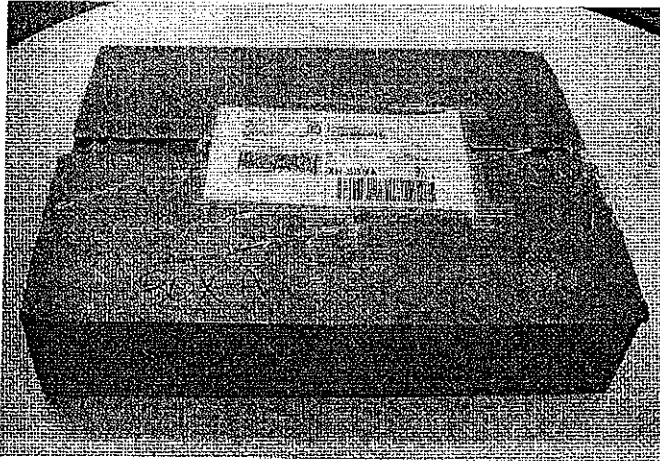
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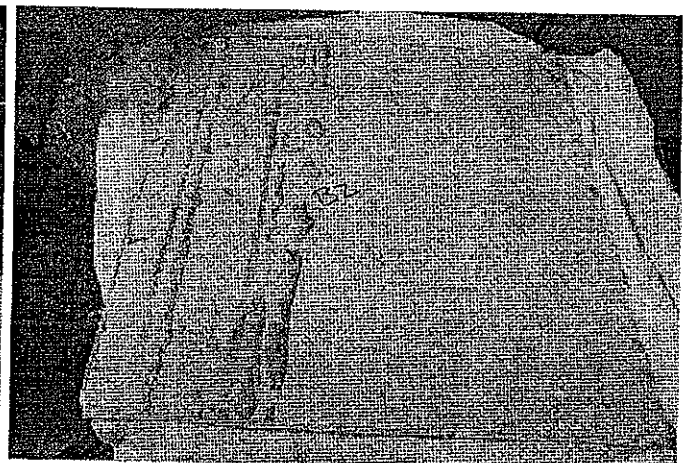
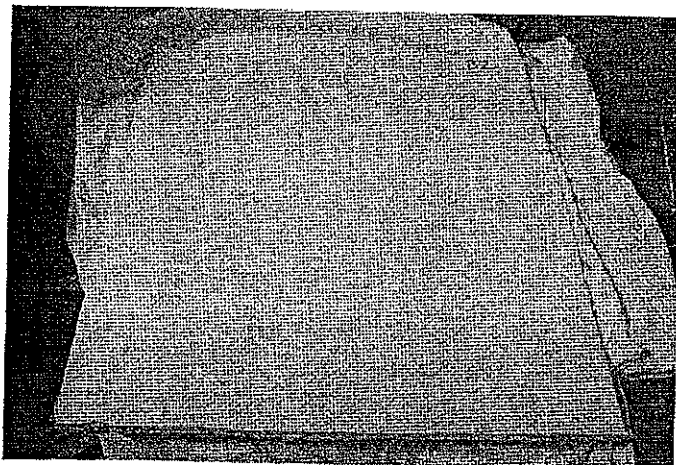
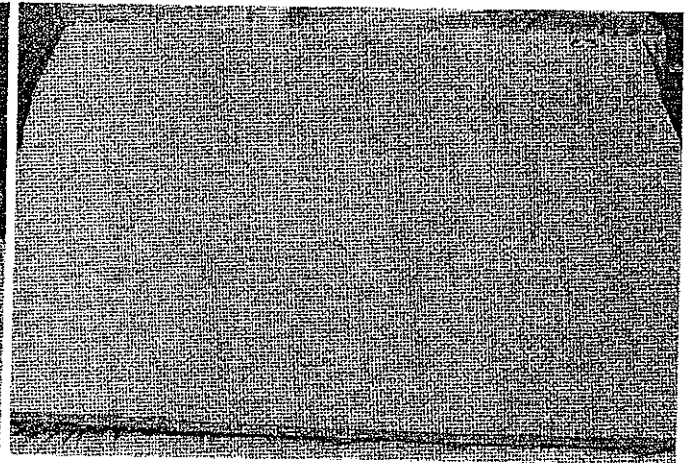
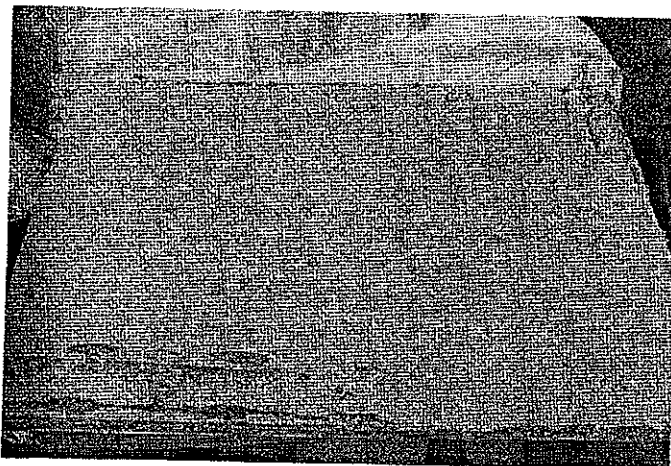
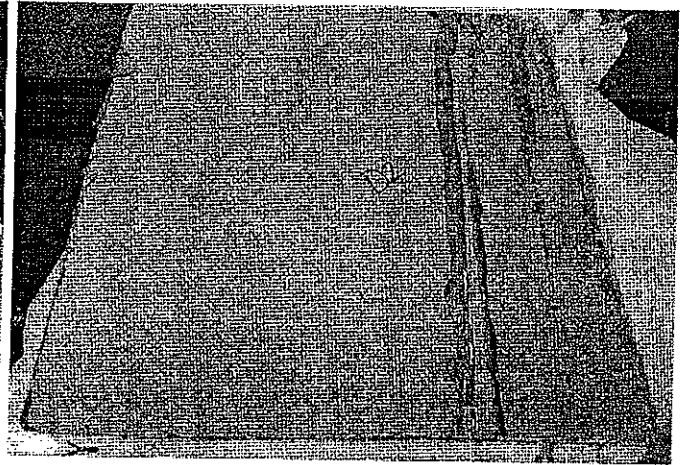
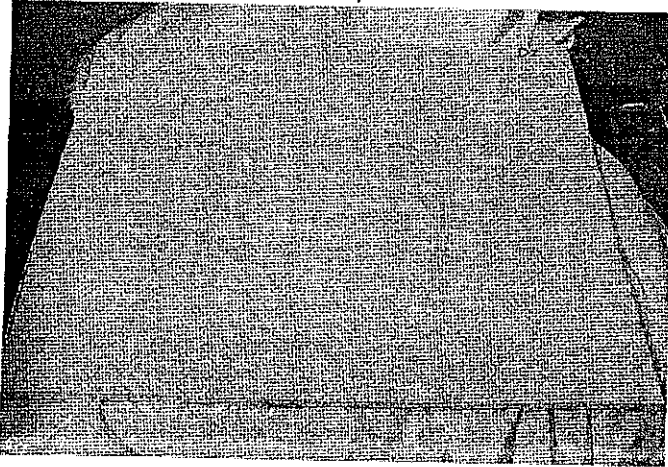
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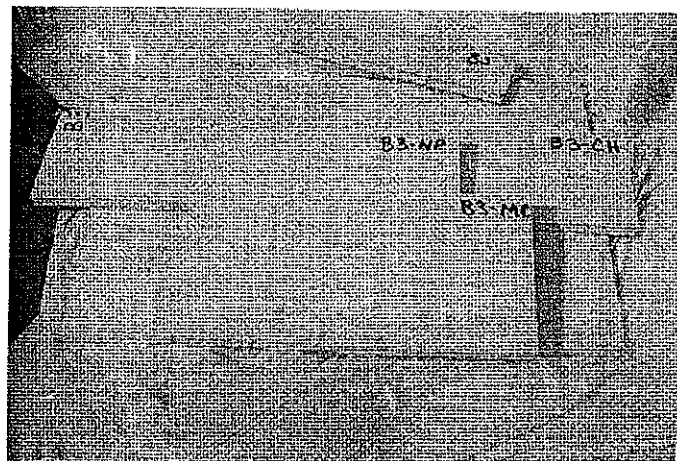
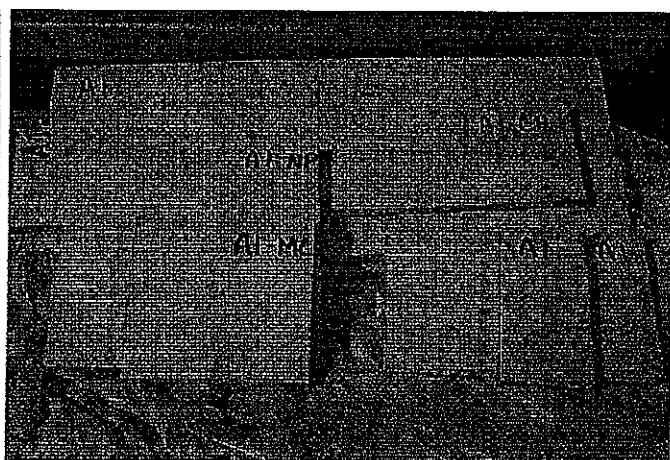
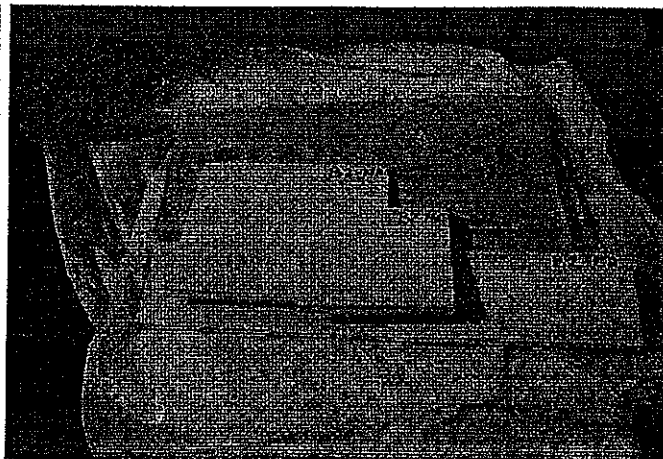
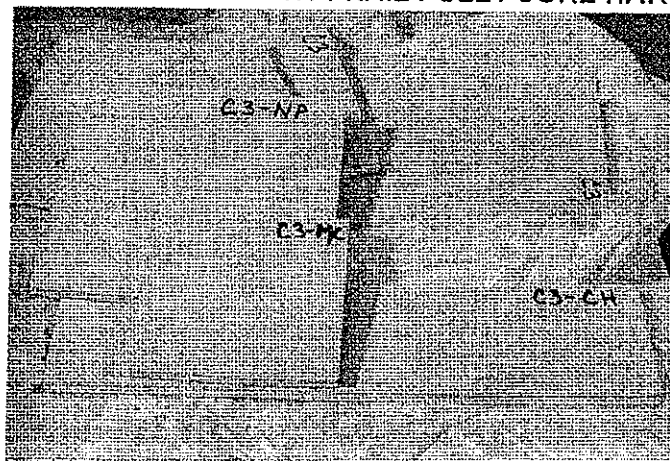
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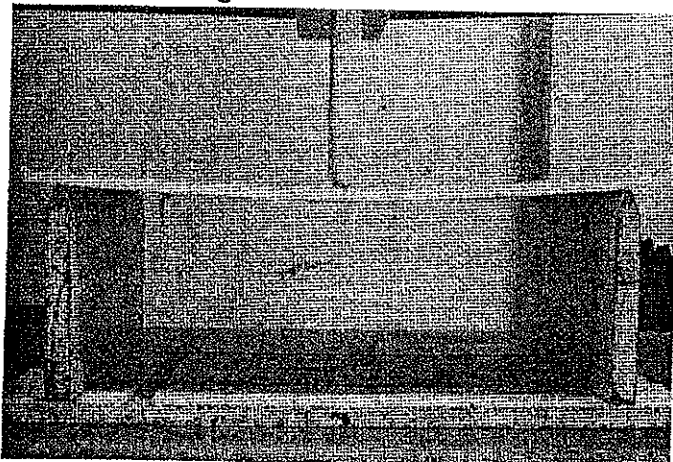
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MOISTURE CONTENT / NAIL PULL / CORE HARDNESS SAMPLES

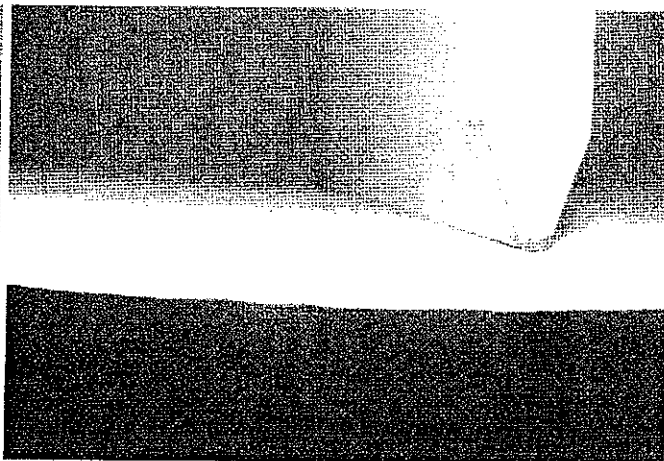


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Flexural Strength Test



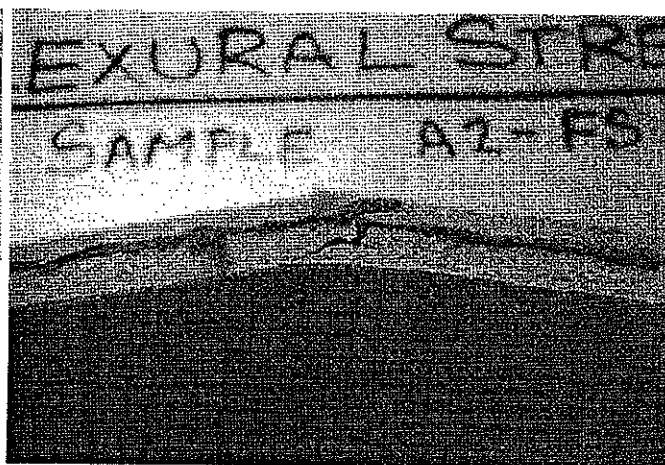
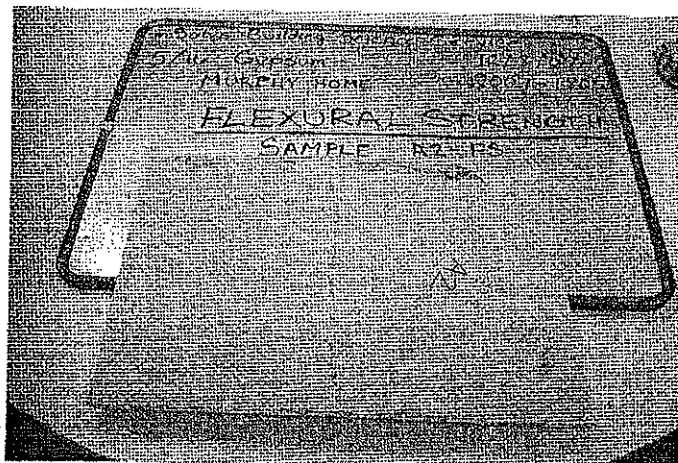
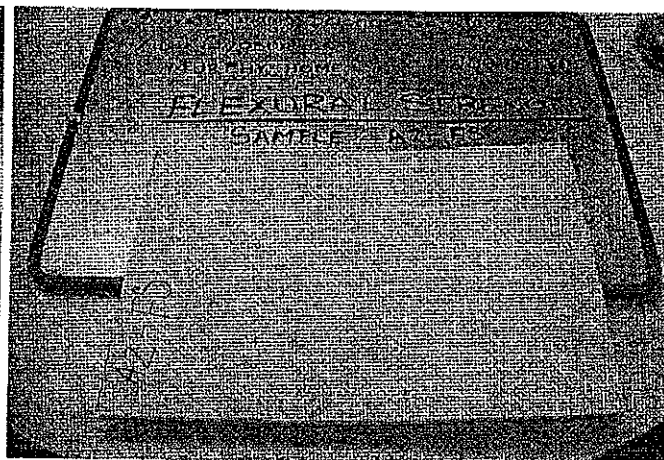
Test Setup



Test Setup

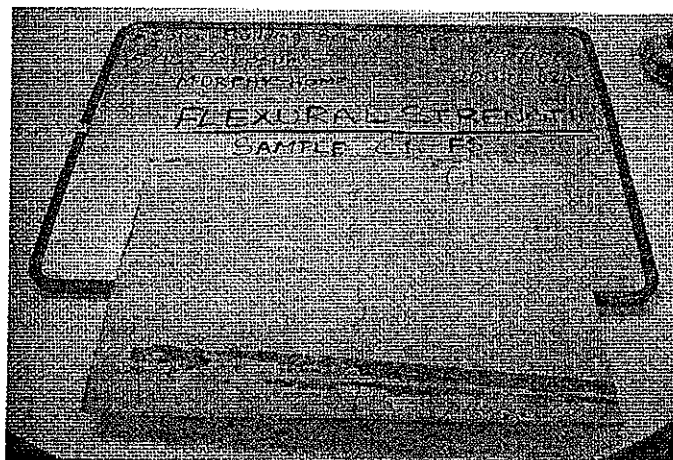
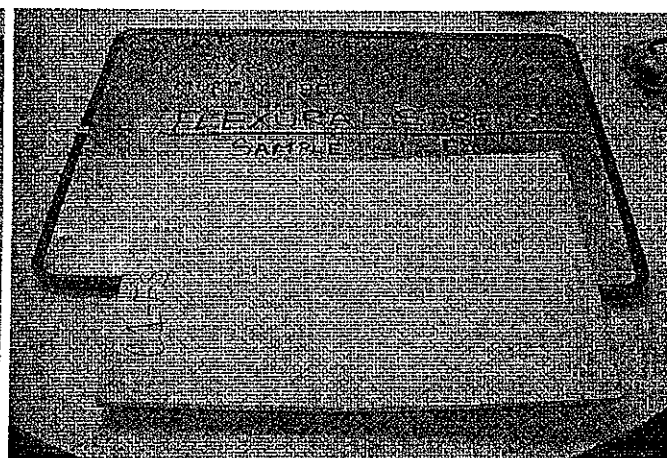
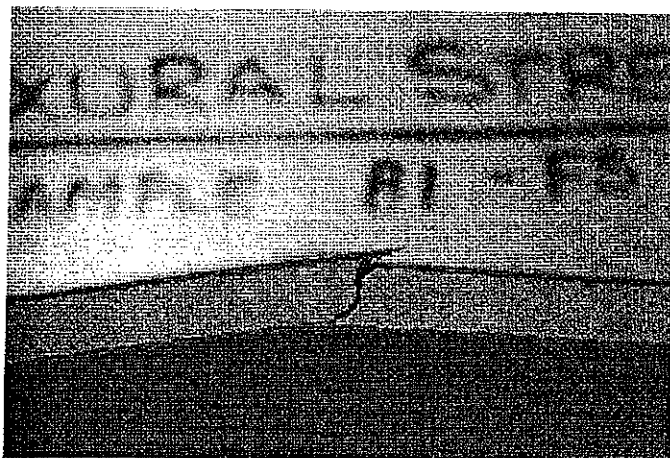
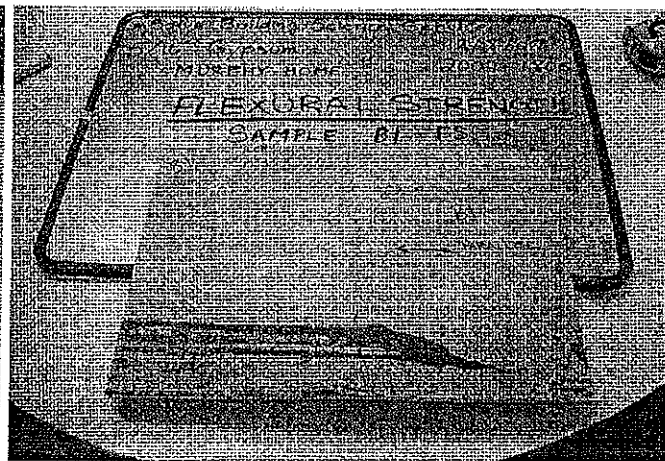
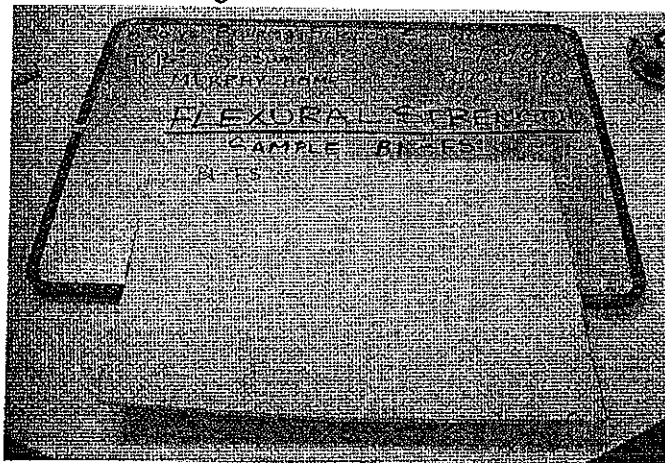


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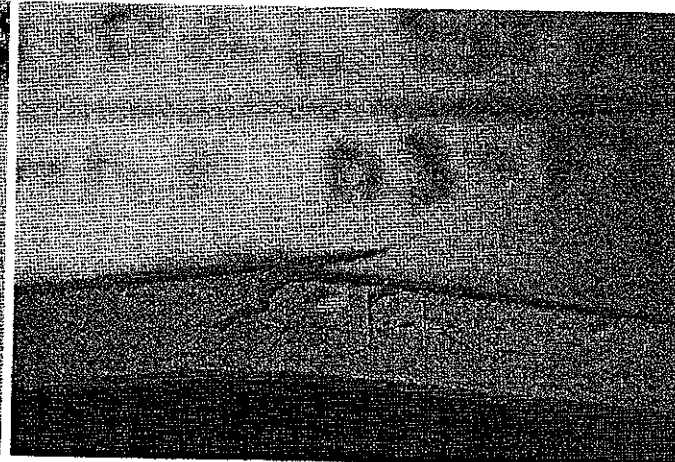
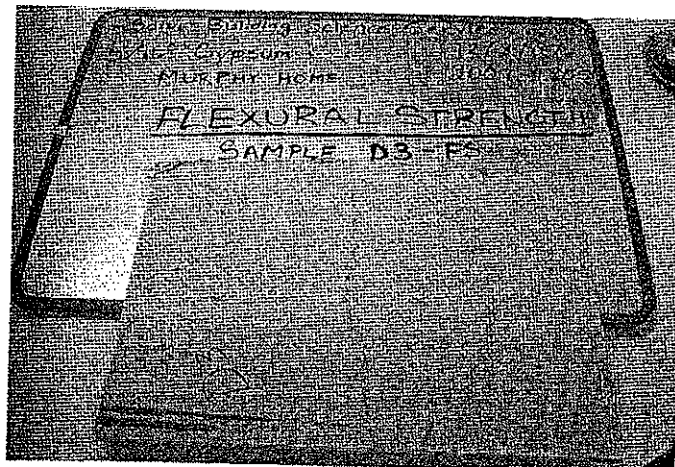
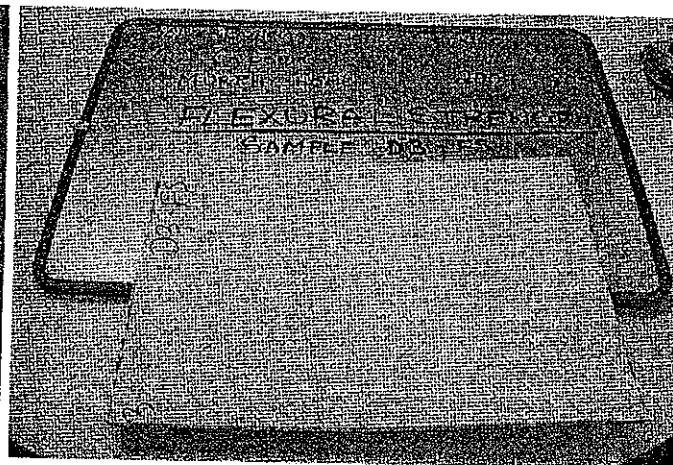
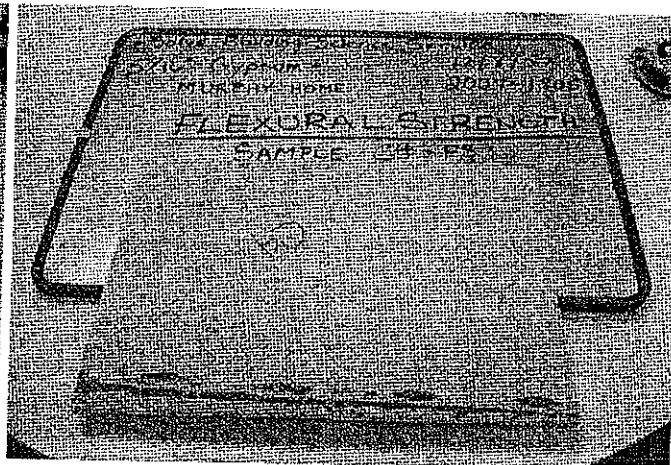
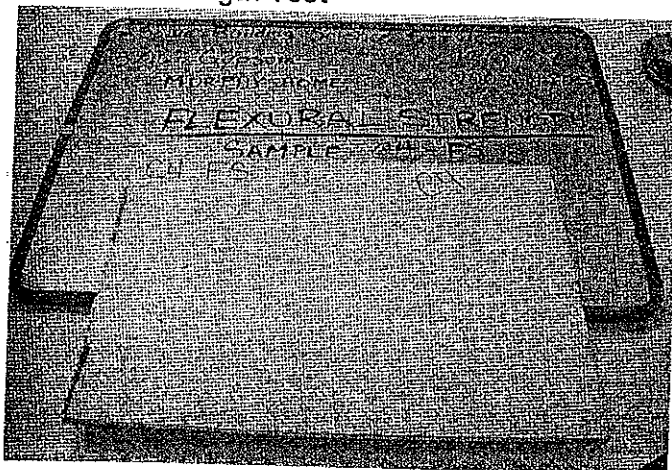
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Flexural Strength Test



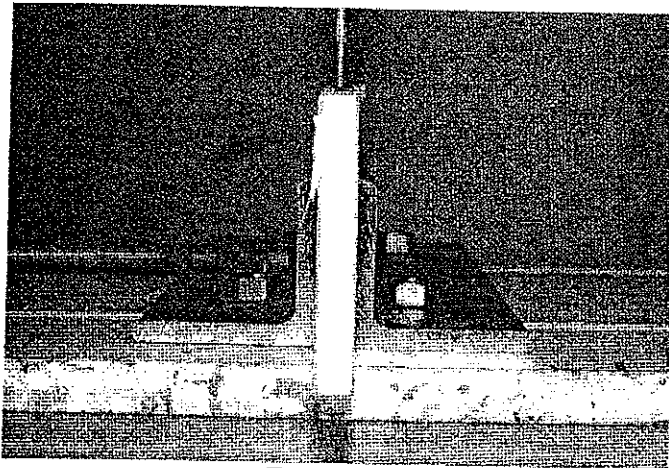
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Flexural Strength Test

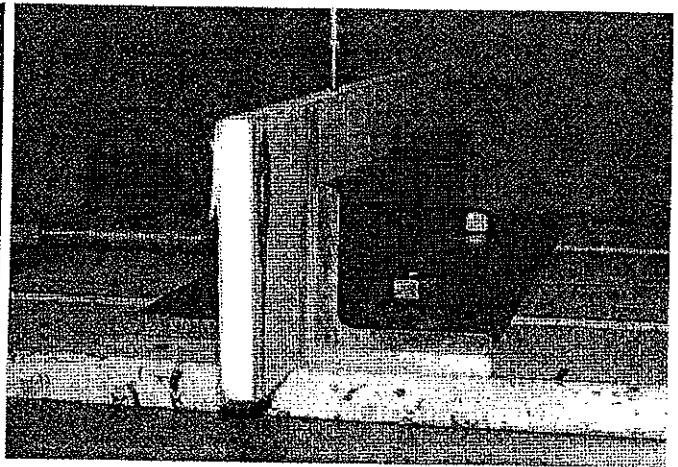


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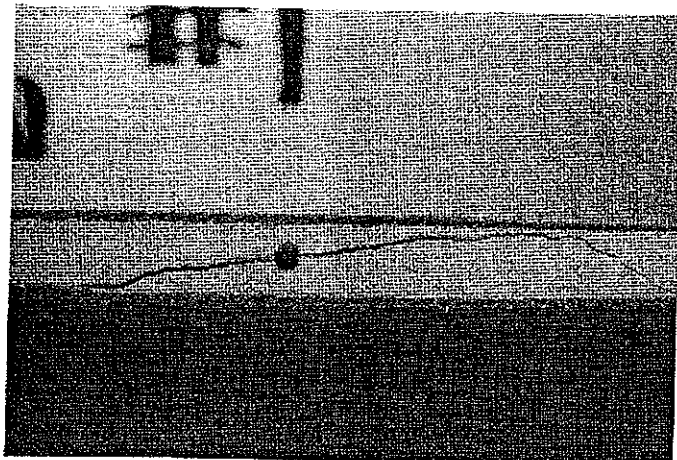
Core Hardness Test



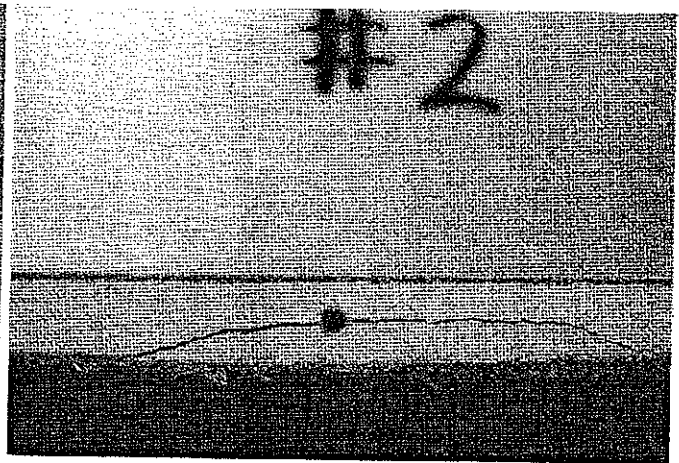
Test Setup



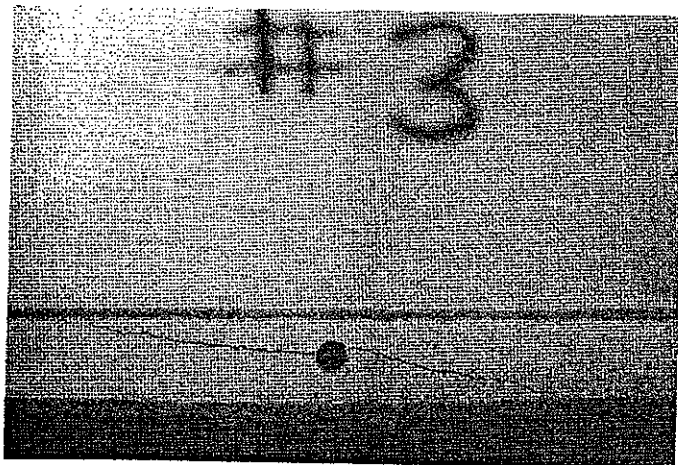
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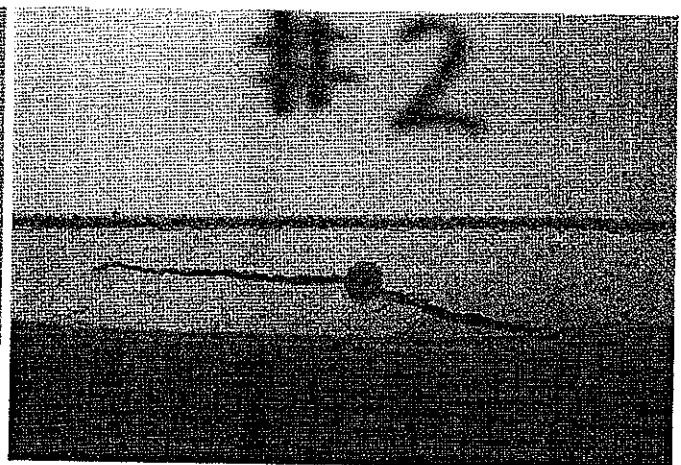
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Typical Failure



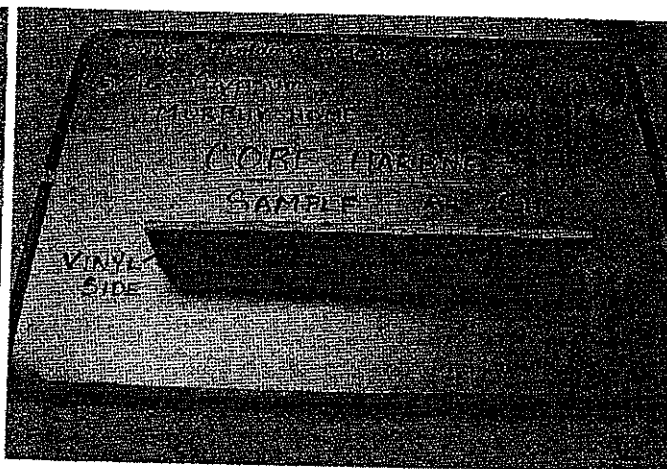
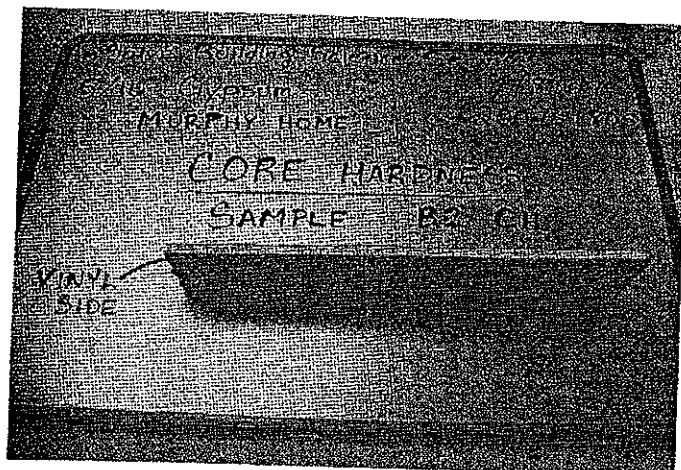
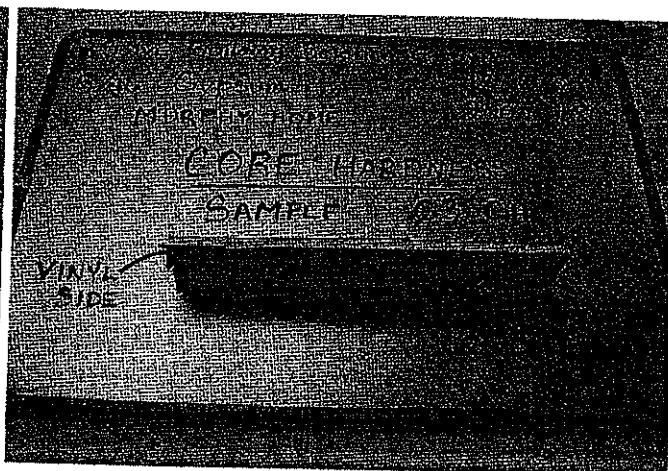
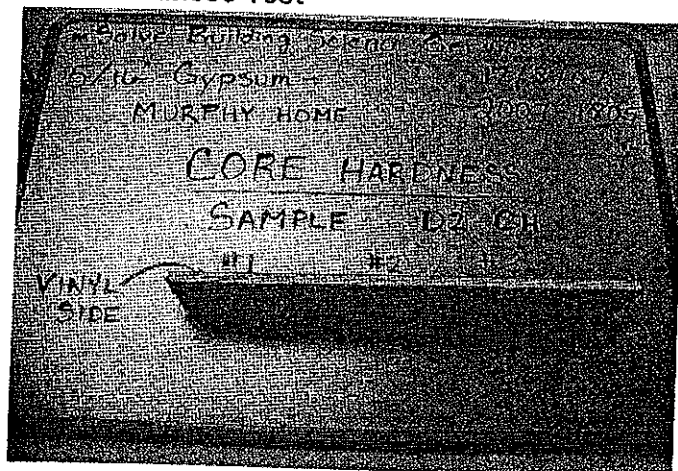
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Typical Failure

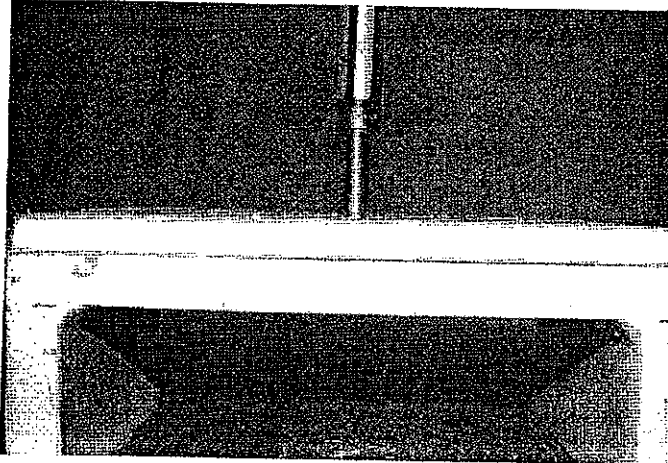
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Core Hardness Test

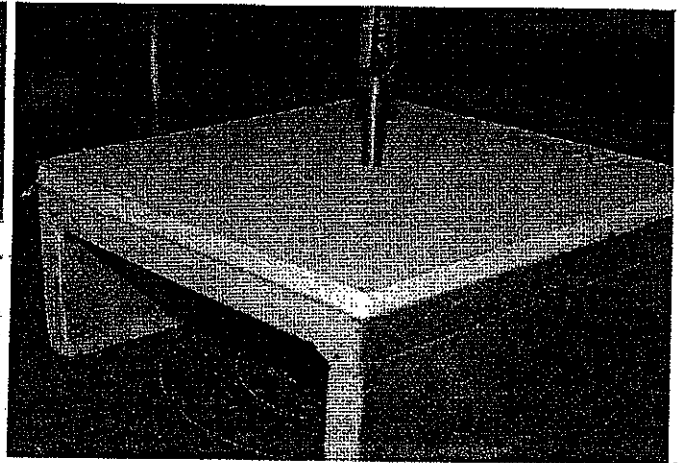


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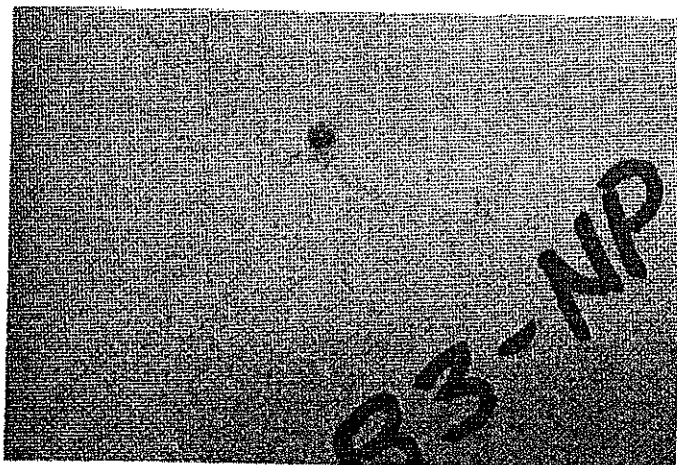
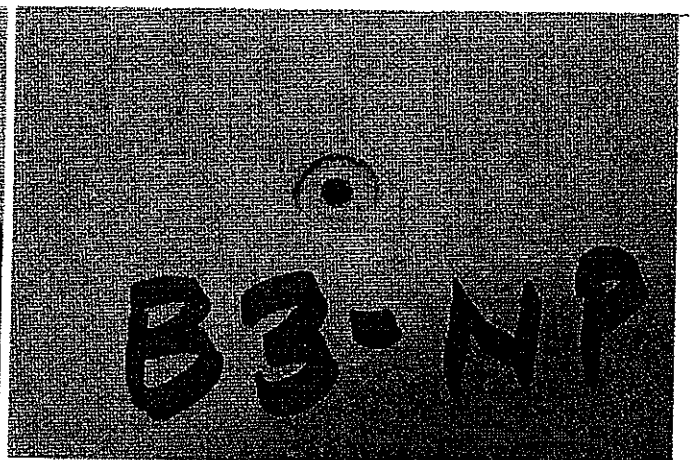
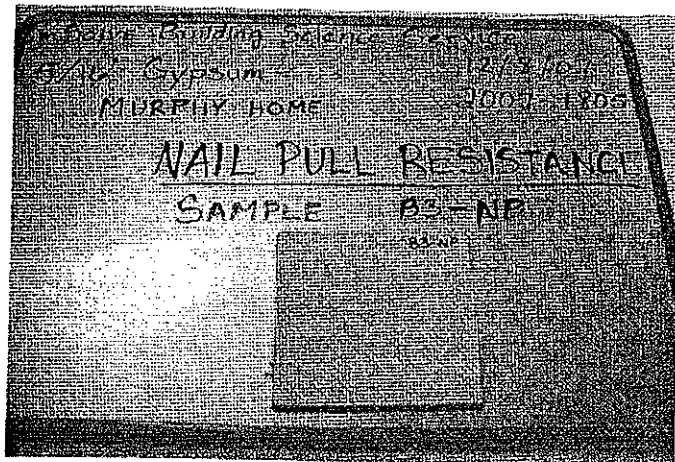
Nail Pull Test



Test Setup

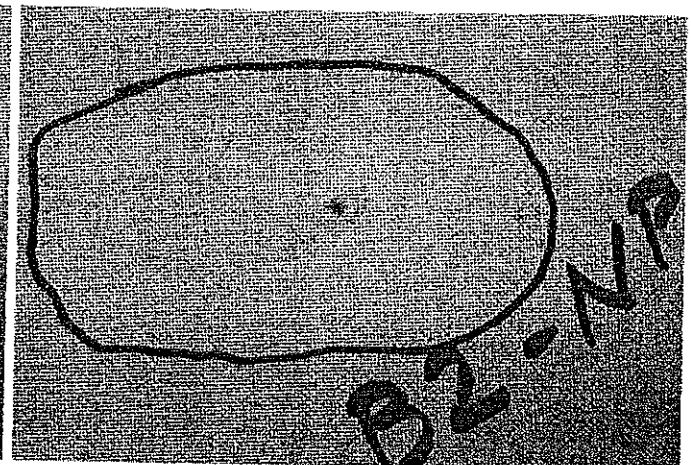
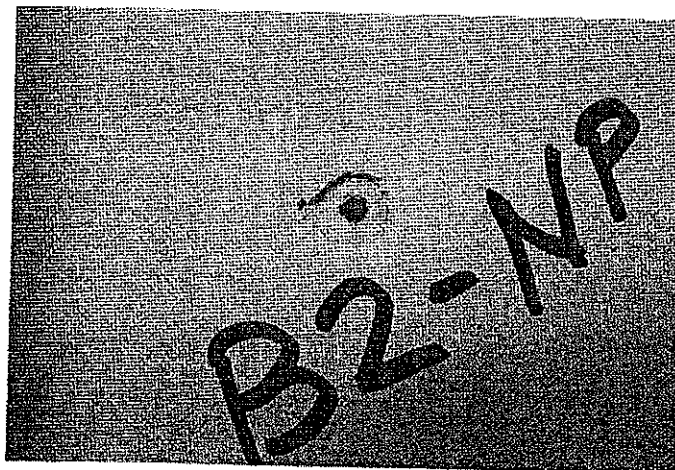
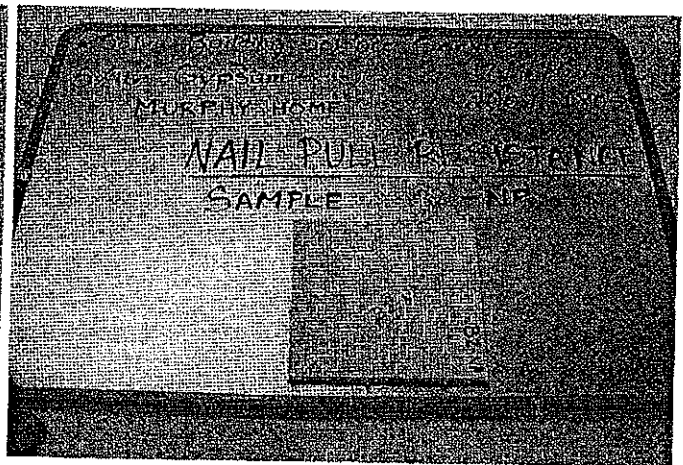
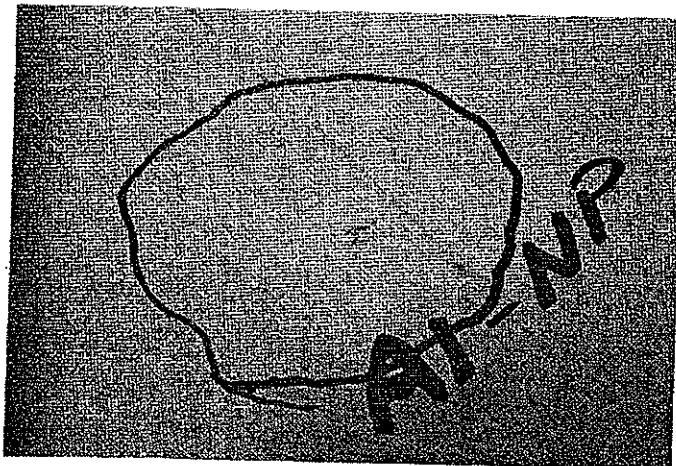
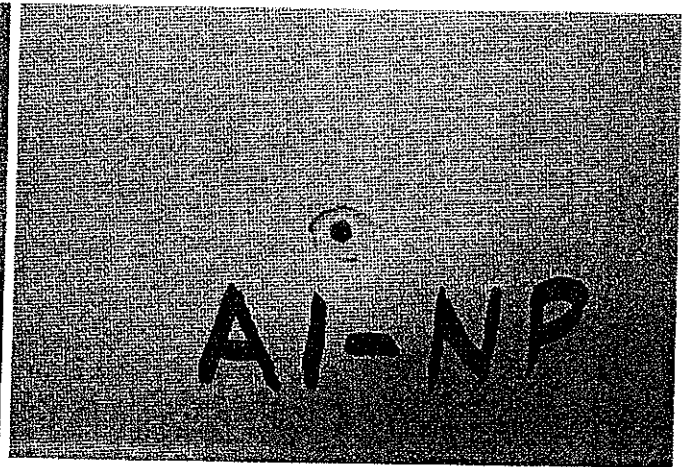
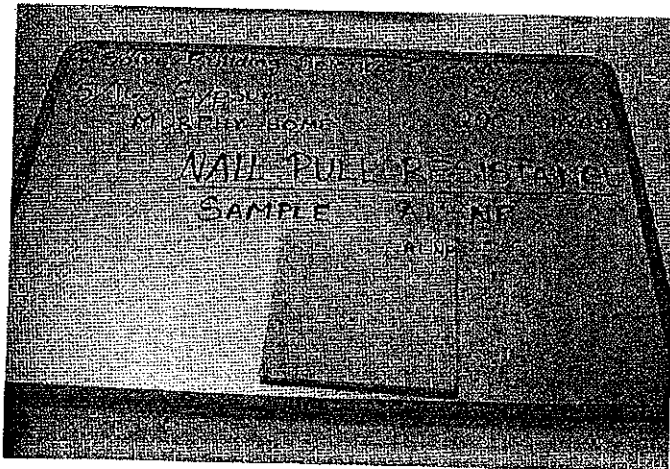


Test Setup



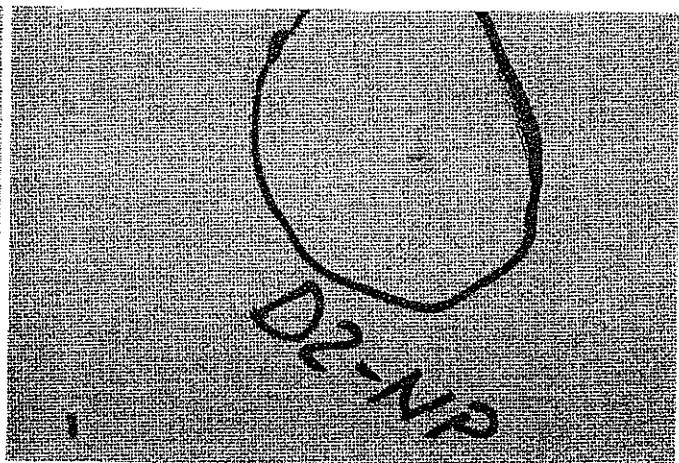
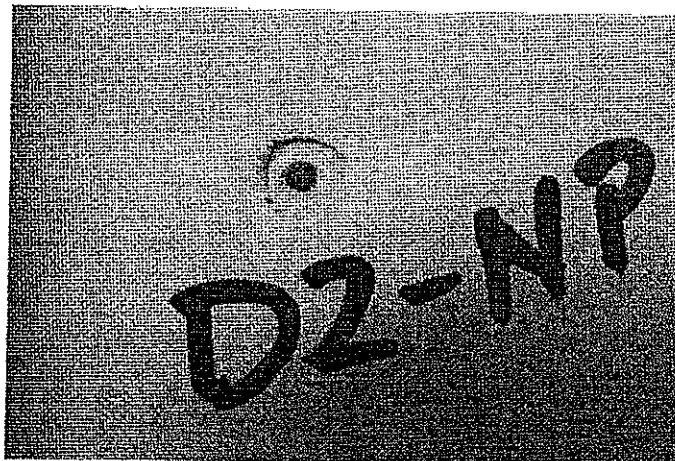
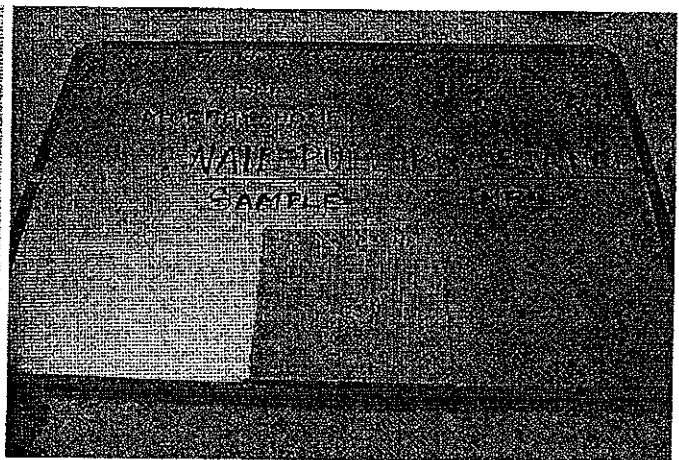
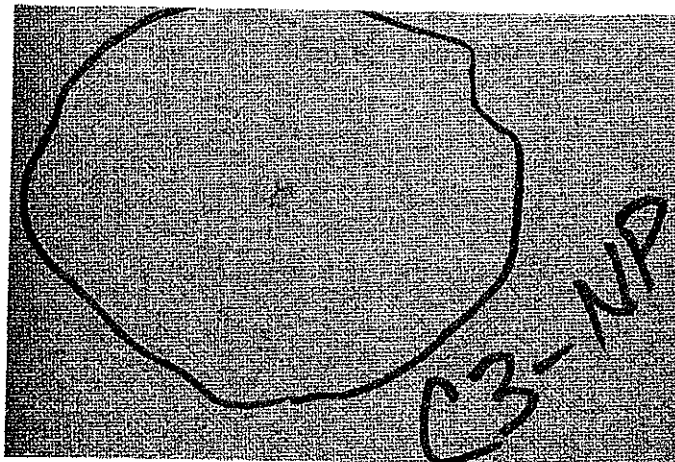
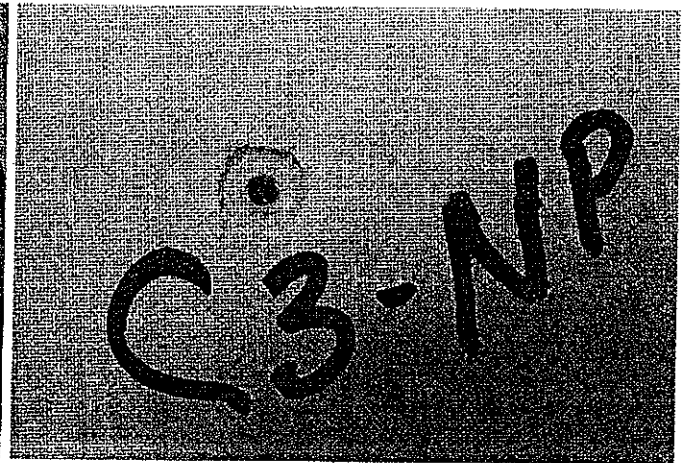
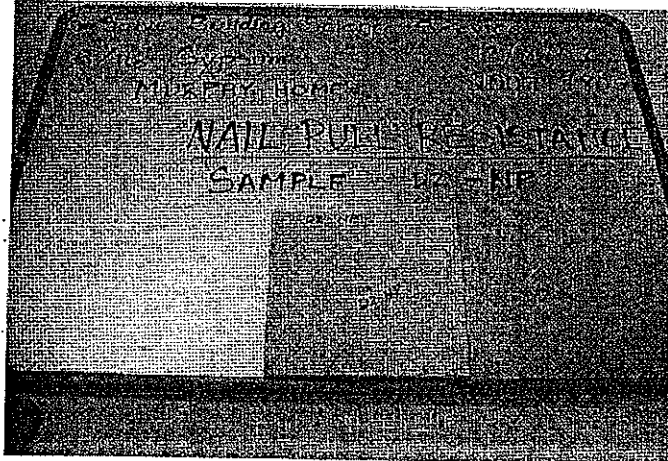
Progressive Engineering Inc.

Nail Pull Test



Progressive Engineering Inc.

Nail Pull Test





TESTING
LISTING
EVALUATION

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NTA 07-11
COMPARISON TESTING OF HAND HELD MOISTURE METERS (HHMM)
WHEN USED ON 5/16-IN VINYL COVERED GYPSUM;
DELMHORST BD2100 PIN TYPE HHMM
AND DELMHORST ACCUSCAN SURFACE TYPE HHMM

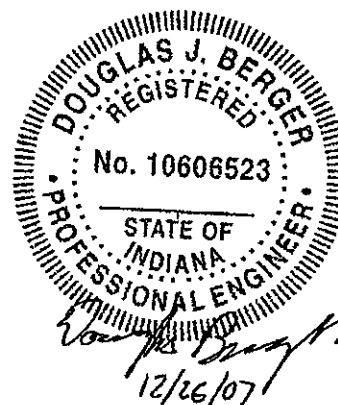
Prepared for:
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3288 Morgan Drive, Suite 100
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Test Report: 120707-26
Issued: December 11, 2007

Prepared By:
Dale Arter
Testing Director

Reviewed By:
Douglas Berger, P.E.
Test Engineer



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SE120707-26

Prepared By: Dale Arter
Reviewed & Approved By: Douglas Berger

Page 1 of 8

Form QA 4.3
Issued/Revised: 12/11/07



1. INTRODUCTION

1.1. GENERAL

Moisture content of gypsum panels is dependant on various construction and environmental conditions. Measuring the moisture content in the field is usually performed using a Hand Held Moisture Meter (HHMM) which fall into the categories of conductance meters or dielectric meters. As stated in ASTM D4444⁴ Sections 3 and 4, these meters take electrical measurements, which are influenced by actual moisture content and a number of material variables, and compare them to calibration tables to produce a moisture content reading. The maximum accuracy can only be obtained by an awareness of the effect of each parameter on the meter output. Also, it should be noted that According to the owner's manual, the dielectric meter uses a reference scale when used on non-wood products. The numbers on this scale are relative or qualitative indications of moisture levels, not percent moisture content.

1.2. OBJECTIVE AND SCOPE

Ritchey and Simpson, PLLC retained NTA Testing Laboratories, Inc. to evaluate various types of HHMMs when used on vinyl covered 5/16-in gypsum in comparison to a version of ASTM D4442² modified for use on gypsum. All tests were conducted at NTA Testing Laboratories facility in Nappanee, Indiana.

2. TEST PROGRAM

2.1. DESCRIPTION OF TEST SPECIMENS

48-in x 90-in Vinyl covered 5/16-in National gypsum panels were obtained from Adorn on September 20, 2007. 24-in x 24-in test specimens were cut from the center of these panels for testing.

Table 1: Materials

Material	5/16-in x 24-in x 24-in National Gypsum covered in vinyl by Adorn
Pin Type Test HHMM	Delmhorst BD 2100, conductance moisture meter
Surface Type HHMM	Delmhorst Accuscan, dielectric moisture meter

2.2. TEST PROCEDURE

This test is conducted in accordance with NTA 07-11¹. Accordingly, 24-in x 24-in gypsum specimens are placed in an environmental chamber set to 90°F and 90% RH. Specimens stay in the chamber until they reach equilibrium moisture content. Equilibrium moisture content is determined by using a pin type HHMM periodically. If the moisture content reading has not changed more than 1% over a 24 hour period, the panels are considered at equilibrium. When the specimens have reached equilibrium, moisture content is recorded using both types of meters at all four corners and at the center of the panel. The specimen is weighed and placed in a drying oven. The drying procedure is based on ASTM D4442² with the exception of the oven temperature is maintained at 60°C for gypsum panels. ASTM D2216³ Section 1.4 states that materials containing gypsum have significant amounts of hydrated water. ASTM D2216³ recommends drying gypsum at 60°C to only evaporate the free water without significant loss of hydrated water. The drying procedure is complete when equilibrium mass has been reached.

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3. TEST RESULTS

Two 5/16-in x 24-in x 24-in vinyl covered gypsum panels were tested by two types of hand held moisture meters and by drying in accordance with ASTM D4442² modified as stated in this report. The results of each method of measuring moisture content are contained in table 2 below, and in the appendix. The HHMM results were direct readings from the meters. Moisture content using ASTM D4442² is calculated using the following equation:

$$MC\% = 100 \cdot (A - B) / B$$

Where:

MC% = Moisture Content of the test specimen

A = Initial (humidified panel) Mass

B = Final (dried panel) Mass

Table 2: Test Results

Specimen	Delmhorst BD2100 moisture content reading	Delmhorst Accuscan moisture content reading	Modified ASTM D4442² measured free moisture content
13065	1.2%	31.8%	1.9%
13067	1.0%	30.2%	1.9%



5. CONCLUSION


Ritchey and Simpson, PLLC retained NTA Testing Laboratories, Inc. to evaluate the accuracy of various types of HHMMs when used on vinyl covered 5/16-in gypsum in comparison to a version of ASTM D4442² modified for use on gypsum.

Table 2: Result Summary

Meter Type	Difference in Moisture Content (%) from ASTM D4442 ² Method
Delmhorst BD2100, Pin Type, Conductance Moisture Meter	.8%
Delmhorst Accuscan, Surface Type, Dielectric Moisture Meter	29.1%

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Dale Arter,
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REPORT REVIEWED BY:  12-26-07

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Test Engineer

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1. NTA Testing Laboratories, Inc. *Gypsum Moisture Content Comparison* NTA 07-11 NTA, Nappanee, IN 2007. 4 pp.
2. American Society for Testing and Materials (ASTM). *Standard Test Method for Direct Moisture Content Measurement of Wood and Wood-Base Materials* ASTM D4442-92. ASTM, West Conshohocken, PA, 2003. 6 pp.
3. American Society for Testing and Materials (ASTM). *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. ASTM D2216-05. ASTM, West Conshohocken, PA, 2005. 7 pp.
4. American Society for Testing and Materials (ASTM). *Standard Test Method for Use and Calibration of Hand Held Moisture Meters* ASTM D4444-92 (2003). ASTM, West Conshohocken, PA, 2003. 6 pp.



FIGURES

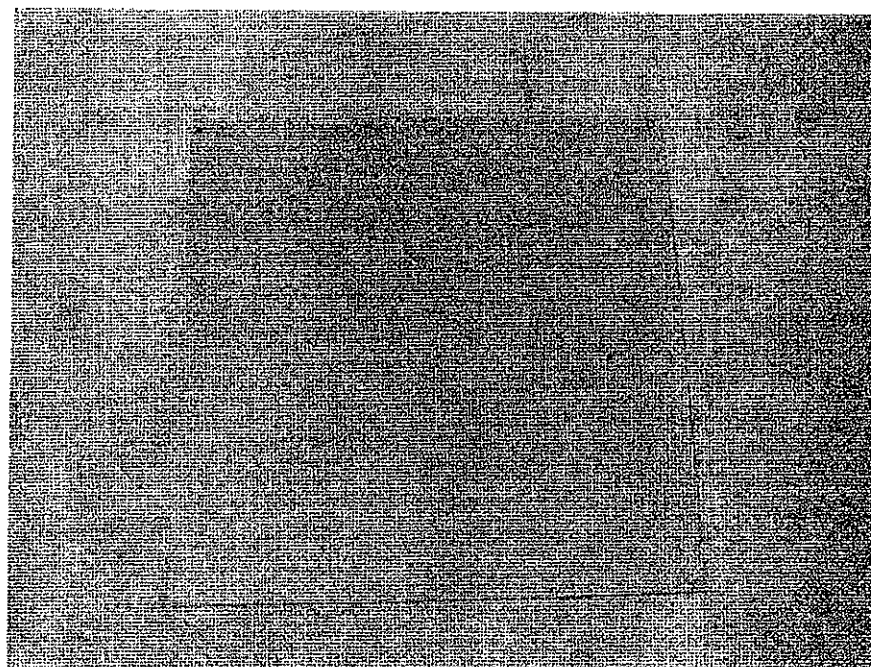


Figure 1: Specimen 13067



Figure 2: Pin Type Moisture Meter

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FIGURES

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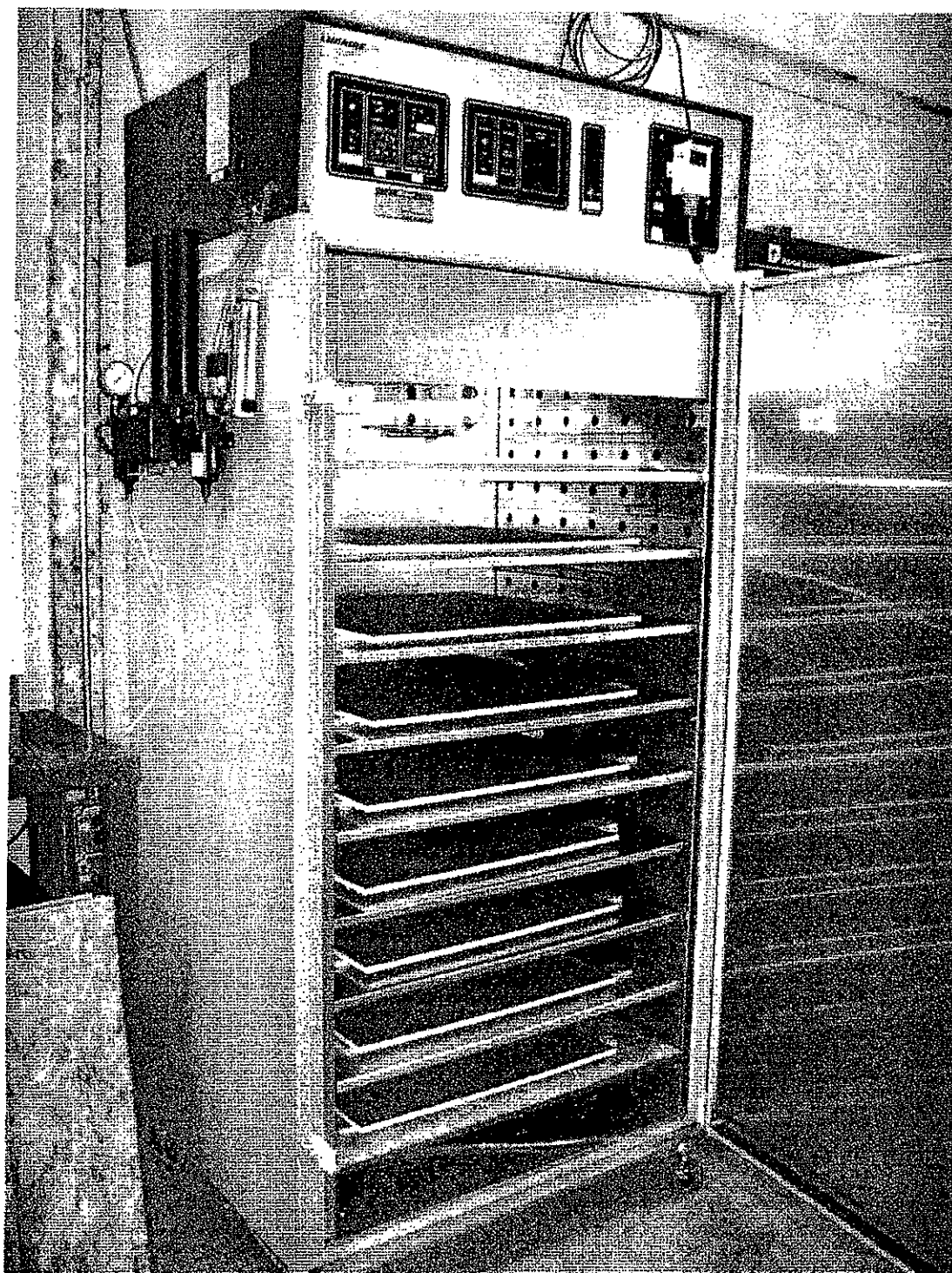


Figure 3: Specimens in Conditioning Chamber

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APPENDIX

SE092407-28 Inclusive
Out

NTA Testing Laboratories, Inc.

NTA 07-11
Gypsum Moisture Content Comparison Testing
Summary Out

General:

Client: Ritchey and Simpson
Job Number: SE120707-26
Performed By: Dale Arter
Test Location: NTA Testing Laboratories, Inc.

Specimen Description:

Manufacturer: National Gypsum
Trade Name/Designation: Vinyl Covered Gypsum
Material Description: 5/16-in. Vinyl covered gypsum adhered by Adorn
Nominal Size: 24-in. wide x 24-in. long
Nominal Thickness: 5/16
Date Received: 9/20/2007
Parent No.: 13049

Conditioning:

Temp: 90 \pm 2°F
RH: 90 \pm 2% RH

Apparatus:

Humidity Chamber: 00765
Sensor: 00623
Pin Type HHMM: 00881
Surface Type HHMM: 00882

Specimen	Conditioning Start	Average Moisture Conditioning Start	Conditioning End	Average Post Conditioning Moisture Content	
	Date/Time	Pin Meter	Date/Time	Pin Meter	Surface Meter
13065	9/22/2007 11:38	0.20	10/3/2007 12:36	1.2	31.8
13067	9/22/2007 11:35	0.22	10/3/2007 12:31	1.0	30.2

Drying Procedure (modified ASTM D4442):

Start Date: 10/3/2007
Start Time: 3:11:00 PM
End Date: 10/5/2007
End Time: 5:52:00 PM

Apparatus:

Convection Oven: 00009
Oven Logger: 00394
Balance: 00003

Drying Temp: 60 deg C

Specimen	Initial Weight	Final Weight	Percent Moisture
13065	2287.42	2243.78	1.9%
13067	2293.79	2250.67	1.9%

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